Essay Review

MICHAEL FARADAY: A BIOGRAPHY, by L. Pearce Williams. 531 pages, diagrams, illustr., 6 × 9 in., New York, Basic Books Inc., 1965. Price, $12.50.

"No one should be recognized a master in any subject who does not know at least the outline of its history. Of course it would be foolish to expect him to have any deep historical knowledge, but he should know the main landmarks and the leading personalities—he should be acquainted with his scientific ancestors.

"This is almost a moral obligation. We might compare it to the obligation for any educated citizen to know the history of his country. The obligation is of the same kind and of the same order . . . for a physicist not to be sufficiently familiar with Galileo and Newton is just as shocking as for an American not to know [of] Washington and Lincoln."

These are the words of George Sarton, historian of science, in "The History of Science and the New Humanism," Harvard Univ. Press, Cambridge 1936, pp. 43–44. Reading them three decades ago motivated the present reviewer to take up what has proved to be a most satisfying avocation, of useful and profitable professional value: namely, to seek out, to read, to record (and to use knowledge thus gained for enhancement of classroom teaching): 1) All book-length autobiographies and biographies (individual and collected) in English of astronomers, chemists, mathematicians, physicists, and of inventors, engineers, and great industrialists; and 2) All of the more important writings in English on the historical development of electrophysics and electrical engineering and on the lives of noted electrophysicists and electrical engineers.

Literal accomplishment of this program is, of course, virtually impossible: but it can be carried to a high degree of completion; and in the thought that much the greater part of the more worthwhile material was located and read and that this material might well be made known to others similarly interested, the reviewer has—over the years—published a continuing series of exhaustive classified bibliographies. Thus, relative to item 1: Thomas J. Higgins, "Book-Length Biographies of Physicists and Astronomers," *Amer. Jour. of Phys.*, Vol. 12, pp. 31–39, 234–239, 1944; Vol. 16, pp. 180–182, 1948; "Book-length Biographies of Chemists," *School Science and Math.*, Vol. 44, pp. 650–655, 1944; Vol. 48, pp. 438–440, 1948; Vol. 65, pp. 139–142, 1965; "Book-length Biographies and Collected Works of Mathematicians," *Amer. Math. Monthly*, Vol. 51, pp. 433–445, 1944; Vol. 56, pp. 310–312, 1949; "Book-length Biographies of Engineers, Metallurgists and Industrialists," *The Bull. of Biblio.*, Vol. 18, pp. 206–210, 235–239, 1946; Vol. 19, pp. 10–12, 1947; and relative to item 2: "A Classified Bibliography of Publications on the History and Development of Electrical Engineering and Electrophysics," *The Bull. of Bibliog.*, Vol. 20, Nos. 3–7, pp. 56–71, 85–92, 115–122, 136–141, 160–161, 1950–1952; "A Biographical Bibliography of Electrical Engineers and Electrophysicists," *Technology and Culture*, Vol. 2, pp. 28–32, 146–165, 1961.

In carrying-out this continuing program, the reviewer has come to appreciate in full the dictions of Charles Lee, "Reading is concentrated living. It is a shortcut to the abundant life. It is everyman's experience made your own. Reading explains, improves, and intensifies living" and of Thomas Carlyle, "All that mankind has done, thought, gained, or been—it is lying as in magic preservation in the pages of books." Thus, "Nothing that was worthy in the past departs; no truth or goodness realized by man ever dies, or can die; but is all still here, and, recognized or not, lives and works through endless changes." And in a yet more pertinent sense, complementing the quotation above, Sarton's "The history of science [and technology] is the only history which can illustrate the progress of mankind"; and yet more pointedly, Emerson's thought, so well utilized by Macaulay, "There is properly no History; only Biography" which—in turn—suggests a paraphrase of Carlyle's sentiment, "The history of physical science

and engineering [Carlyle, . . . 'the world' . . .] is but the biography and autobiography of great men."

In such thought, from among the thousands of personally-read biographies entailed in the bibliographies detailed above, the reviewer would select, as that which in a first reading enthralled him (and yet does) and which stands in his opinion as first among the dozen or so "best of all" in their conjoined account of the personal life and professional accomplishment of the individual concerned, S. P. Thompson's "The Life of William Thomson; Baron Kelvin of Largs," London, Macmillan, 1910, 2 vols.

And to this select group the reviewer added, when he read it soon after publication, Williams' masterly biography of the man whose work aroused Kelvin's youthful and life-long sustained interest in electrical science, Michael Faraday: whose "father was a blacksmith, and his education was limited to attendance at Sunday school, but in a lifetime of intellectual labor he transformed himself, most professionals agree, into the greatest experimental scientist who ever lived. He induced the first electric current, developed the first dynamo and with it the possibility of electric power, created the science of electrochemistry and with it a primary implement of modern industry, blasted the first big breach in the Newtonian universe and laid down the foundations of both classical and contemporary field theory" (*Time*, July 23, 1965, pp. 86–90).

The general prerequisites to easy reading and ready grasp of content, the easy flow of narrative, the lucidness of account, the skillfulness of exposition, and the clarity of explanation of technical and scientific detail and aspect are well-elucidated by an earlier reviewer: "In this definitive new biography by Dr. L. Pearce Williams, who teaches the history of science at Cornell, Faraday is described with affection and his work with impressive lucidity. Anybody who knows enough about electricity to screw in a light bulb can follow most of Faraday's experiments as they are described in this book, and the occasional puzzling paragraph can only intensify the suspense of a scientific epic that is also a harrowing, intellectual thriller." (*Time*, ibid).

The thoroughness of underlying research, the mosaical structuring of content, and the polish of exceptional scholarship are well-delineated in "Faraday, the great master of experiment, has at last found the biographer he has long deserved in Prof. Pearce Williams, who has spared himself from no toil in tracing the details of his subject's family origins and early life, in describing every facet of his attractive personality and in studying with a critical eye the multitude of his experiments, using not only printed sources but also much hitherto unpublished manuscript material. His book takes its place as the definitive work on Faraday." (London *Times Literary Supplement*, Aug. 12, 1965, p. 692).

In certain specialized philosophical aspects, however, some differ* with one of Williams' basic tenets. Thus, "It is indeed unfortunate that this readable and comprehensive biography, obviously the product of painstaking scholarship, should have its many virtues seriously jeopardized by the basic point of view from which it was written. . . . In tracing Faraday's theoretical achievements, Williams has attempted a grandiose synthesis. Thus, he insists on a single, hidden basis for essentially all of Faraday's theory construction during his most productive 25-year period." (J. F. Spencer, *Science*, Vol. 148, June 25, 1965, p. 1710). Relative to such and other similar remarks concerning the role of "Naturphilosophie" in Faraday's work, it is of interest to read Williams' own remarks in the introduction to his subsequent complementing book, "The Origins of Field Theory," Random House, New York, 1964, 148 pp. (paperback); whereof Bernard S. Finn, Curator, Division of Electricity, Smithsonian Institution, Wash., D.C. has written: This "represents a condensation and an extension of L. Pearce Williams' important biography of Michael Faraday, published last year. On the one hand, although Faraday dominated the unfolding drama of field theory, his vast contributions cannot be given the previous detailed treatment. On the other hand, the roots of Faraday's ideas are here exposed with much greater assurance. It is Williams' contention—which

* "He that publishes a book runs a very great hazard, since nothing can be more impossible than to compose one that may secure the approbation of every reader."

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now appears without the more tentative expression of the biography—that Faraday was deeply indebted to the nature philosophy of Kant and Schelling and to the atomic theory (of points surrounded by force systems) of Roger Boscovich.

"Such a viewpoint is provocative. It has stirred up debate among the specialists, and discussion can be expected to continue for some time. The general reader should therefore be aware that some of Williams' assumptions are interpretations which enjoy limited support . . ."

Finn's own opinion is manifest in his concluding remark: "Although Faraday may have found comfort in his limited understanding of Boscovich and the German philosophers, they were clearly not leading him around by the intellectual nose." (*Science* Vol. 150, Sept. 2, 1966, p. 1093).

Finally, it is of interest to note Williams' own, somewhat wry remark in his introduction to the just-cited book: "My estimate of the relative worth of the contributions of Faraday and Maxwell to the development of field theory will also, I suspect, meet with opposition. Here my defense is somewhat stronger; I have only followed Maxwell's own estimate."

In buttress, complement, illumination and exploration of various remarks in Williams' book, the reviewer found it of value to follow reading of it by a re-reading of the several dozen earlier-published biographies and treatments of Faraday and his work, as listed in the bibliographies cited above: from, especially, John Tyndall's "Faraday as a Discoverer" (published the year after Faraday's death, 1868, and of which his longtime friend and co-worker Tyndall wrote, "It is not my intention to lay before you a *life* of Faraday in the ordinary acceptance of the term. The duty I have to perform is to give you some notion of what he has done in the world, dwelling incidentally on the spirit in which his work was executed, and introducing such personal traits as may be necessary to the completion of your picture of the *philosopher*, though by no means adequate to give you a complete idea of the man.") to the recent D. K. C. MacDonald, "Faraday, Maxwell and Kelvin," Heinemann, London, 1964, 143 pp.; Anchor Books, Garden City, L.I., 1964 and W. T. Scott, "A Bibliographic Reference Table for Faraday's Papers on Electricity," *Natural Philosophy*, Vol. 3, pp. 75–94, 1964 and—recently and continuingly—R. J. Seeger "Michael Faraday: His Scientific Insight and Philosophical Outlook," *The Physics Teacher*, Vol. 5, pp. 104–111, Mar. 1967. Yet further, it proved of profit and interest to reread the similar content on Kelvin, Maxwell and Heaviside, all of whom knew Faraday, were stimulated by his writings, and expanded in chronological succession the domain he had initiated (for example: as remarked by J. W. Herival, "Prerequisites for Creativity in Theoretical Physics," *Scientia*, Vol. CI, pp. 347–352, 1966), "Maxwell only developed his theory of electromagnetism after a profound study of Faraday's experimental researches on the subject"; as, in fact, is well-evidenced in the fascinating "Origins of Clark Maxwell's Electric Ideas: as described in familiar letters to William Thomson [Lord Kelvin]," edited by Sir Joseph Larmor, Cambridge University Press, 56 pp., 1937; as is stressed in A. Bork, "Physics Just Before Einstein," *Science*, Vol. 152, pp. 597–603, 1966, delineating the development of electromagnetic theory as a major activity before relativity theory, wherein he notes in Heaviside's citation on receiving an honorary degree from Göttingen in 1905 the phrase, "[he was] of the followers of Maxwell easily the first."; and as elaborated in R. A. R. Tricker, "Early Electrodynamics: The First Law of Circulation," Oxford, Pergamon Press, 217 pp., 1965; in A. O'Rahilly, "Electromagnetics, a Discussion of Fundamentals," London, Longmans Green and Co., 884 pp., 1938, recently reissued; and—above all—in E. T. Whittaker's exhaustive study, "A History of the Theories of Aether and Electricity," revised and enlarged edition, Vol. I. "The Classical Theories," Vol. II, "The Modern Theories," London, T. Nelson, New York, Philosophical Library, 1951, 1953; re-issue T. Nelson, London, 1958.

In conclusion, it is to be remarked that any reader of Williams' biography of Faraday can well enhance his pleasure thereof by a subsequent reading of P. J. McLaughlin's, "Nicholas Callan, Priest-Scientist (1779–1864)," Clonmore and Reynolds Ltd., Dublin; Burns and Oates Ltd., London, 1965, 128 pp., a sparkling account of the "Irish priest, professor of natural philosophy at St. Patrick's College, Maynooth, near Dublin, from 1826 till his death in 1864, [who] was a pioneer in

the development of electromagnetism as a source of power. He constructed great batteries and electromagnets, invented the induction coil in 1836 and discovered the principle of self-excitation in dynamo-electric machines two years later. Yet his name finds no place in works devoted to the history either of science or of technology; . . . [and] One result of this neglect has been that the credit for discoveries and inventions properly due to Callan has been given to others, to Ruhmkorff for the invention in 1851 of the induction coil and to Werner Siemens for the discovery in 1866 of the principle of the self-induced dynamo," to quote the words with which N. H. de V. Heathcote opens his lengthy, complementing "Essay Review: N. J. Callan, Inventor of the Induction Coil," *Annals of Science*, Vol. 21, pp. 145–167, 1965; an individual also well detailed in P. J. McLaughlin, "Some Irish Contemporaries of Faraday and Henry," *Proc.*, Royal Irish Academy, Vol. 64, Sec. A, pp. 1–35, 1964.

And in Carlyle's thought that "History is the essence of innumerable biographies," a thought expanded in T. J. Higgins, "The Function of Biography in Engineering Education," *Journal of Engineering Education*, Vol. 32, pp. 82–92, 1941; in H. I. Sharlin, "The Scientist in Biography," *Bulletin of the Atomic Scientists*, pp. 27–28, Nov. 1963; and in J. Z. Fullmer, "Davy's Biographers: Notes on Scientific Biography," *Science*, Vol. 155, pp. 285–291, 1967, to name but several such; and mindful of Collins, "next to poetry, biography is the most satisfying reading of all ages: instructive to youth, inspiring to maturity, solacing to old age. Its human interest, its preoccupation with man, brings it close to our understanding and to our emotions," the reader who closes with regret Williams' treatment of Faraday may yet prolong and refract the pleasures derived therefrom by a reading of some or all of the numerous reviews of it (as listed, say, in the classified critical bibliography to appear in *Isis* in 1967; and in Williams' recently-published "Michael Faraday and the Physics of 100 years ago," *Science*, June 1967, pp. 1335–1342).

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Book Reviews

NONLINEAR ELECTRON-WAVE INTERACTION PHENOMENA, by Joseph E. Rowe. 591 pages, diagrams, 6 × 9 in. New York, Academic Press Inc., 1966. Price, $18.00.

Author Rowe gives us a very thorough and exhaustive treatment of the mathematical techniques used to analyze the large signal behavior of klystrons, traveling wave amplifiers, and crossed-field microwave devices.

Preliminary chapters justify the need for nonlinear analysis and describe why a Lagrangian formulation rather than an Eulerian formulation is required. A detailed treatment of various types of rf circuits used in microwave devices is given with some interesting analyses which discuss the use of equivalent circuit equations.

Despite the apparent rigor of this chapter, no real justification appears for the use of these equivalent circuits when applied later in the book to relativistic situations. The author then gives a detailed treatment of the various types of space-charge models used in large signal analyses. He provides various curves useful to those wishing to carry out their own numerical analyses.

Several chapters are devoted to the types of analyses appropriate to the different types of microwave tubes, including forward and backward-wave traveling wave tubes, forward and backward-wave crossed-field amplifiers, and klystrons, with relativistic treatment, changes in beam potential, etc. Here, Rowe gives an excellent review of the work of others as well as his own, and to some extent shows the relation between these various types of analyses. In later chapters he shows how the analysis may be extended to deal with finite diameter beams and to determine the types of tapers required in a *TWT* to obtain optimum efficiency.

The book is thorough, and will be an extremely useful reference. However, it suffers from the fault that one is never quite certain, despite rather optimistic claims, whether large signal theory is really accurate. Very little comparison between theory and experiment is given. The only really impressive comparison is given in the